HDR-89-AOP-4
September 1988

HOT DRY ROCK GEOTHERMAL ENERGY DEVELOPMENT PROGRAM

Annual Operating Plan Fiscal Year 1989

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DISCLAIMER

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FY89 AOP/HDR

I. EXECUTIVE SUMMARY

With completion of the repairs of EE-2 wellbore in FY88, the major effort in FY89 will be directed toward the remaining preparations for the Long-Term Flow Test (LTFT) now scheduled to begin in September 1990. Procurement of components and equipment and installation of the surface system will continue through this and the next fiscal year to be ready for the LTFT in September 1990.

Reservoir experiments will consist of pressurization and flow tests to establish further characteristics of the Phase II reservoir, particularly operating water losses. Laboratory studies will continue work on fracture healing and complete adsorption tests for chemically-reactive tracer work.

Cleaning and relining of the EE-1 pond to meet New Mexico State requirements, started in FY88, will be completed. Reanalysis of seismic data and automation of seismic data techniques will continue. Monitoring for environmental information, routine operations, security, health and safety training, and reporting activities will continue.

II. INTRODUCTION

II.1 Program Goal

The US resource base of hot but dry rock is very large, on the order of 500,000 quads. Technology for extracting useful heat from hot dry rock systems is evolving. The technical feasibility of extracting thermal energy from hot, low-permeability rock formations has been established through work at Fenton Hill, New Mexico. A small "Phase I" hot dry rock reservoir was created, expanded, and flow tested in the 1977-1980 period. A much larger "Phase II" reservoir was created in 1983, and has been flow tested briefly. These accomplishments have been supported by parallel developments in drilling, well completion, and logging instrumentation as well as analytical techniques to understand reservoir behavior. Microseismic fracture mapping and tracer studies, in addition to hydraulic and thermal data, contribute to the reservoir analysis. The overall program goal is now to develop an industrially exploitable technology base.

II.2 Program Objectives

A) To develop HDR drilling, hardware and instrumentation technology for energy extraction and conduct a successful energy extraction field experiment of the Phase II reservoir.

B) To verify that the environmental consequences of HDR development are acceptable.

C) To improve HDR technology to the point where electricity could be produced commercially from a substantial number of known hot dry rock resource sites in a cost range of 5 to 8 cents /kWh.

D) To evaluate the performance of the Fenton Hill Phase II reservoir by 1992. That performance consists of system operating characteristics, including thermal drawdown, energy output, reservoir impedance, and water consumption.

II.3 Program Activities in Funding Year

The FY89 program activities include:

A) Continuation of procurement and installation of LTFT system components.

B) Field pressurization tests to better estimate water requirements for LTFT.

C) Cleaning and lining of the 1-M-gal water storage pond at EE-1 well.

D) Complete 2D and 3D thermal/fluid dynamic and mass transfer model with pressure and temperature-dependent rock projections.

E) Complete automation of fracture mapping techniques and reanalysis of seismic data.

F) Complete adsorption tests in laboratory for chemically-reactive tracer work.

G) Continue laboratory experimental work of possible fracture healing.

H) Continue water analysis and seismic monitoring for environmental effects.

I) Technology transfer will include interface with industry on the LTFT and participation in technical meetings.

II.4 Key and Control Milestones

Project	O	N	D	J	F	M	A	M	J	J	A	S
Fenton Hill Operations			C1				C2					
Scientific and Engineering Support												C3

Milestone Number and Description
C1=Start pressurization tests.
C2=Complete EE-1 storage pond.
C3=Complete Laboratory experiments on adsorption of chemically-reactive tracers.

II.5 Projected Funding Year Accomplishments

A) Procurement and installation of 50% of LTFT system components.

B) Field pressurization tests for improved estimates of water losses for LTFT.

C) Cleanout and rebuild EE-1, 1-M-gal water storage pond.

D) Complete 2D and 3D thermal/fluid dynamic and mass transfer model using pressure and temperature-dependent continuum analysis.

E) Complete automation of fracture mapping techniques and reanalysis of MHF seismic data.

F) Complete adsorption tests in laboratory for chemically-reactive tracer work.

G) Complete fracture healing laboratory experimental work.

H) Conduct environmental water analysis and seismic monitoring.

I) Technology transfer will include interface with industry on the LTFT and participation in technical meetings.

II.6 Work Breakdown Structure

Level		Identifier	Title
I	Category		HOT DRY ROCK PROGRAM
II	Task	1	FENTON HILL SITE OPERATIONS
III	Project	12	Phase II Energy-Extraction System
III	Project	13	Phase II Ancillary Activities
III	Project	14	Test Site Support and Utilities
II	Task	2	SCIENTIFIC AND ENGINEERING SUPPORT
III	Project	21	Tools and Instrumentation
III	Project	22	Reservoir Engineering
III	Project	23	Technology Application

III. PRIOR YEAR DATA

III.1 Significant Accomplishments

A) Completed repair of Wellbore EE-2 by redrilling into existing reservoir (see footnote on next page) to improve pressure capability and provide for logging at greater depth for the Long-Term Flow Test. Completed well with new full-length 7-in. casing.

B) Procured some components and continued installation work on the surface system for the Long-Term Flow Test.

C) Continued industrial cooperation and technology transfer.

D) Reanalyzed microearthquakes from the massive hydraulic fracturing experiment using improved mapping methods and 3-point method and initiated programming effort toward automation.

E) Completed prototype Borehole Acoustic Televiewer (BAT) and surveyed Borehole EE-2A.

III.2 Prior Year Funding ($ Thousands)

Project	Management	In-House Effort	Subcontracted Effort	LTFT Equipment	TOTAL
Fenton Hill Operations	120	1660	2250	240	4270

Project	Management	In-House Effort	Subcontracted Effort	LTFT Equipment	TOTAL
Scientific and Engineering Support	120	1430	300		1850
TOTAL	240	3090	2550	240	*6120

III.3 Prior Year Manpower (average for entire fiscal year)

Project	Management	In-House	Subcontract Effort	TOTAL
Fenton Hill Operations	1.0	12.0	5.0	18.0
Scientific and Engineering Support	1.0	8.0	1.0	10.0
TOTAL	2.0	20.0	6.0	28.0

IV. FUNDING YEAR RESEARCH PLAN

IV.1 Project Title and Objectives for FY89

In consonance with the overall program objectives and pursuant to the program status at the end of FY88, the specific objectives of the Hot Dry Rock Geothermal Energy Development Program for FY89 include preparations for the Long-Term Flow Test (LTFT).

During FY89 and continuing into FY90 the research effort of the program will concentrate on those efforts which will aid eventual interpretation of the LTFT and reservoir assessment. These efforts include development of chemically-reactive tracers, which allow estimation of internal temperatures within a reservoir, and development of 3-dimensional models of fluid, heat and tracer transport within the reservoir, and seismic analysis focusing upon fault plane analyses.

IV.2 Work Statement Summary

The work breakdown structure was provided in Section II.6. For the reader's convenience, we briefly summarize the work statement in this section, and provide details in the next section.

LANL will perform the following:

*Note that this exceeds $5220K funding for FY88 by $900K, the extra amount carried over from FY87 for FY88 redrilling expenses.

Fenton Hill Operations

Phase II Energy Extraction System

A) Conduct the LTFT system procurement and installation at a pace in FY89 such that installation is completed by September 1, 1990.
   1. Complete pump house with valves and piping; provide working drawings.
   2. Procure and install valves and make-up pumps; provide working drawings.
   3. Accomplish separator design study; provide report.

B) Conduct pressurization tests to estimate water loss for LTFT; issue preliminary report.

C) Clean and line the EE-1 one million gallon water storage pond.

D) Design and modify the wellhead tower; provide working drawings.

Phase II Ancillary Activities

A) Log wells during reservoir tests.

B) Acquire water for LTFT and complete study of water transportation system.

C) Under environmental monitoring, continue water analyses and seismic monitoring.

Site Support and Utilities

A) Improve electric power supply for increased load of LTFT.

B) Maintain HDR logging tools, vans, and computers.

C) Maintain data acquisition equipment and software, and communication equipment

D) Maintain site safety and emergency equipment such as backup power supplies, noxious gas detectors, fire fighting equipment, and continuation of equipment operation safety courses.

E) Maintain water supply and water treatment equipment.

F) Maintain site buildings, trailers, wellheads and equipment.

G) Coordinate Fenton Hill site activities with US DOE Los Alamos Area Office, US Forest Service, New Mexico State Engineers Office, New Mexico Bureau of Economic Geology, New Mexico Environmental Improvement Division, and LANL Health and Safety Division.

Scientific and Engineering Support

Tools and Instrumentation

A) Conduct wellbore logging as required in support of reservoir testing, and continue instrument calibration and maintenance.

Reservoir Engineering

A) Conduct series of sustained pressurization tests to determine water losses as functions of pressure.

B) Complete modeling 2D and 3D thermal/fluid dynamic and mass transfer incorporating non-linear pressure and temperature dependence in homogeneous. continuum model of reservoir.

C) Complete automation of fracture mapping techniques, reanalysis of MHF seismic data, and fault plane spectra analysis.

D) For chemically-reactive tracer work, complete adsorption tests in laboratory. and continue development of techniques for analyzing tracers at expected low concentrations (parts per billion).

E) Continue study of fracture healing in laboratory under simulated HDR reservoir conditions of temperature and pressure.

Technology Applications

A) Continue transfer of tool and equipment information; interface with industry on LTFT participation; coordinate with technology transfer societies; and prepare articles for tech transfer.

Estimated Funding and Manpower Distribution for FY89 Projects

Project	Manpower Expected (Man-Mo)	Personnel Cost Expected ($K)	Contract. Procurement & Services Costs Expected ($K)	Total Cost Expected ($K)
FENTON HILL OPERATIONS				
Phase II Energy Extraction System	132.0	1156.0	556.0	1712.0
Phase II Ancillary Activities	24.0	260.0	24.0	284.0
Test Site Support and Utilities	26.0	330.0	269.0	599.0
SCIENTIFIC AND ENGINEERING SUPPORT				
Tools and Instrumentation	13.0	147.0	17.0	164.0
Reservoir Engineering	48.0	662.0	21.0	683.0
Technology Application	10.0	148.0	10.0	158.0
TOTAL PROGRAM		2703.0	897.0	3600.0

IV.3 Work Statement Details Broken Down to Project Level (See Section II.6 for Work Breakdown Structure)

12. Phase II Energy Extraction System

This project encompasses design of the Phase II surface system and procurement of hardware components. Based upon analysis of the Initial Closed Loop Flow Test of 1986 and brief tests following EE-2A redrilling, reservoir operating parameters are now known. enabling specification of the LTFT design, and start of procurement and construction activities in FY87. Procurement and installation of loop components continued in FY88. but procurement of major equipment such as circulating pumps was delayed. due to funding limitations. In FY89 LANL will continue to procure hardware and services necessary to provide the surface system to carry out the Long-Term Flow Test (LTFT). Procurements will include valves, piping and control systems. Major items such as the high-pressure pumps will not be procured entirely in FY89 due to their high cost, but specifications will be prepared and competitive bids sought for procurement in both FY89 and FY90.

Field experiments will be continued to learn more about the nature of the Phase II reservoir as well as developing and improving reservoir interrogation techniques. A series of special flow experiments will be carried out in FY89 to evaluate the water requirements for the LTFT.

FY89 RESOURCE REQUIREMENTS ($FY89)			
Manpower (man-mo): Expected Value	132.0		
Personnel Cost: Value ($K)			1156.0
CONTRACTS, PROCUREMENTS AND SERVICES (CP&S) COSTS			
Internal and Allocated Costs ($K)		70.0	
Hardware Procurements and Testing ($K)		326.0	
Installation and Field Testing ($K)		160.0	
CP&S Subtotal ($K)			556.0
FY89 EXPECTED TOTAL PROJECT COST ($K)			1712.0

13. Phase II Ancillary Activities

This project includes frequent periodic downhole measurements in the EE-2A and EE-3A wellbores, using LANL instruments for evaluation of the condition of the wellbores.

The downhole measurements to be performed include temperature surveys, spinner surveys, caliper logs, and microseismic mapping during pressurization tests, using Fenton Hill wells plus Precambrian monitoring wells. During flow testing, temperature and spinner logs and occasional gamma logs will be made during the flow tests to assess resulting dynamic changes in the reservoir.

This project also includes environmental surveillance and documentation as required to satisfy state and federal environmental agency needs and to protect the government from spurious claims of biotic, hydrologic or induced seismic damage. The effort consists primarily of local and downhole seismic monitoring during and immediately following downhole pressure/flow operations, plus sampling and chemical/biotic analysis of site water supplies. Water supply from the on-site well is analyzed organically on a monthly basis and full chemical analysis is conducted annually. In addition, occasional noise-level and illumination measurements are made.

Included also is effort attendant upon proper waste fluid disposal in accordance with the Program's NPDES permit. A Liquid Waste Discharge Plan was approved by New Mexico State Oil Conservation and Environmental Improvement Divisions and was initially implemented in FY85 and modified in FY87.

In accordance with the Liquid Waste Discharge Plan, the EE-1 storage pond will be cleaned and relined for leak monitoring.

FY89 RESOURCE REQUIREMENTS ($FY89)			
Manpower (man-mo): Expected Value	24.0		
Personnel Cost: Value ($K)			260.0
CONTRACTS, PROCUREMENTS AND SERVICES (CP&S) COSTS			
Commercial Logging Contract ($K)		10.0	
EE-1 Pond Repair ($K)		14.0	
CP&S Subtotal ($K)			24.0
FY89 EXPECTED TOTAL PROJECT COST ($K)			284.0

14. Test Site Support and Utilities

Work encompassed by this project is directed at maintaining the site in the condition necessary to perform planned experimental operations. Included are: access and on-site road grading, graveling and snow removal, building and utility maintenance, housekeeping, maintenance of the flow loop, uninterruptible power supply (UPS) system and freeze protection system, maintenance of emergency vehicle and facilities, maintenance of water storage and transfer facilities, multiple handling of workover towers, site security, handling of visitors, and site safety.

Formal safety-related efforts include: periodic site safety inspections by LANL Health, Safety & Environment Division representatives and the New Mexico Environmental Improvement Division; preoperational safety meetings, potential toxic effluent monitoring and site crew briefings, and annual first-aid and CPR recertification courses.

Water Supply is a continuing programmatic concern because in New Mexico, as in other southwestern states, water is a scarce commodity whose utilization is carefully controlled by state law. The intent in FY89 is to provide from the local supply -- through careful scheduling and utilization -- adequate water for workover/redrilling pressure tests and flow tests. This work includes handling and periodic treatment of water on-site. Treatment is limited largely to pH and bioform control, and to precipitation of suspended solids in working ponds when required.

FY89 RESOURCE REQUIREMENTS ($FY89)			
Manpower (man-mo): Expected Value	26.0		
Personnel Cost: Value ($K)			330.0
CONTRACTS, PROCUREMENTS AND SERVICES (CP&S) COSTS			
Internal and Allocated Costs ($K)		49.0	
Site Maintenance Contract ($K)		140.0	
Security Guard Contract ($K)		70.0	
Safety and Sanitation ($K)		10.0	
CP&S Subtotal ($K)			269.0
FY89 EXPECTED TOTAL ACTIVITY COST ($K)			599.0

21. Tools and Instrumentation

This project includes the checkout, calibration and routine maintenance of existing downhole instruments, flow system instrumentation, data acquisition and recording equipment, and ancillary test equipment associated with the energy-extraction loop at Fenton Hill. It also includes checkout, calibration and routine maintenance of the instruments and data acquisition systems used for environmental surveillance. Checkout comprises visual inspection, physical checks and electronic bench and autoclaved tests. Instruments are calibrated against precision laboratory equipment with ultimate traceability to NBS standards. Routine maintenance involves: removal, and repair or replacement of defective components and reinstallation; cleaning; lubrication; replacement of fluids; and performing other prescribed servicing procedures.

FY89 RESOURCE REQUIREMENTS ($FY89)			
Manpower (man-mo): Expected Value	13.0		
Personnel Cost: Value ($K)			147.0
CONTRACTS, PROCUREMENTS AND SERVICES (CP&S) COSTS			
Internal and Allocated Costs ($K)		17.0	
CP&S Subtotal ($K)			17.0
FY89 EXPECTED TOTAL PROJECT COST ($K)			169.0

22. Reservoir Engineering

This project includes Reservoir Thermal/Fluid-Dynamic Design and Analysis, Reservoir Microseismic Instrumentation and Analysis, Reservoir Size Assessment Technique, and Reservoir Geochemical Processes. It represents the scientific core of the program in which: (a) thermal/fluid dynamic modeling of the reservoir is formulated, verified, and iterated as necessary; (b) downhole experiments are planned and directed; (c) acquired data are analyzed in depth; and (d) the reservoir configuration is analyzed and studied. Included is laboratory and analytical support which provides measurements of thermophysical and structural properties and expert assistance with complex computer modeling.

One of the most important technology elements to be developed for HDR systems is reservoir size assessment. A potential industrial developer must be able to convincingly demonstrate the "size" (power output capability and longevity) of the reservoir. Although the LTFT, a protracted thermal drawdown test, will permit a size assessment, this technique is subject to problems with uniqueness, and requires long testing periods. Thus, this project also includes the development of a complementary technique for reliably and nondestructively determining the effective energy accessibility of a large multifracture HDR reservoir in a relatively short time. Techniques to be tested include chemically-reactive tracers and rock dissolution kinetics.

The desire to possibly operate the surface loop at lower pressure has raised new questions about the possibility of calcite deposition in the surface plumbing. If the pressure is low enough for carbon dioxide to leave the liquid phase, calcite scaling will result. The preliminary design of the surface loop includes gas separators to remove excessive amounts of carbon dioxide from the geothermal fluid. Also, a sodium bisulfate injection system is being studied for scavenging of excess oxygen, which promotes corrosion.

Acoustic techniques, particularly the study of microseismic events, are the only means by which direct information about reservoir changes can be obtained from locations away from the boreholes. Work will continue to gain as much information as possible from the seismic data obtained during the massive hydraulic fracturing experiment conducted during prior fiscal years. More realistic estimates of the accuracy of microseismic locations calculated via the Precambrian method are being developed. Spectral analyses and fault plane solutions for events will be carried out. LANL will automate much of the processing of the seismic data acquired during experiments, providing results from future pressurization tests on a much more timely basis.

FY89 RESOURCE REQUIREMENTS ($FY89)			
Manpower (man-mo): Expected Value	48.0		
Personnel Cost: Value ($K)			662.0
CONTRACTS. PROCUREMENTS AND SERVICES (CP&S) COSTS			
Internal and Allocated Costs ($K)		21.0	
CP&S Subtotal ($K)			21.0
FY89 EXPECTED TOTAL PROJECT COST ($K)			683.0

23. Technology Applications

This project is a continuing effort devoted to promulgating system engineering and resource information, as well as hardware developments, from the HDR Program to the energy-producing and other interested industries and to cognizant counterpart government and educational institutions. Reciprocally, such liaison affords access to current industrial technology for application in the HDR Program.

Presentation of programmatic efforts and results will be made at a variety of technical conferences such as: Geothermal Resources Council (GRC) Annual Meeting: Stanford Geothermal Workshop; American Geological Union; Energy Technology Conference and Exhibit; and Program Development Council Meetings.

Scientific and engineering liaison will also be continued with foreign HDR-related programs, data from which contribute directly to the success of the Fenton Hill Project.

FY89 RESOURCE REQUIREMENTS ($FY89)			
Manpower (man-mo): Expected Value	10.0		
Personnel Cost: Value ($K)			148.0
CONTRACTS. PROCUREMENTS AND SERVICES (CP&S) COSTS			
Internal and Allocated Costs ($K)		10.0	
CP&S Subtotal ($K)			10.0
FY89 EXPECTED TOTAL ACTIVITY COST ($K)			158.0

IV.4 Milestones

Milestone dates are presented in the accompanying chart.

IV.5 Projected Funding Year Accomplishments

A) Procurement and installation of 50% of LTFT system components.

B) Field pressurization tests to better estimate water losses for LTFT.

C) Cleanout and line EE-1, 1-M-gal water storage pond.

D) Complete 2D and 3D thermal/fluid dynamic and mass transfer model.

E) Complete automation of fracture mapping techniques and reanalysis of MHF seismic data.

F) Complete adsorption tests in laboratory for chemically-reactive tracers.

G) Complete fracture healing laboratory experimental work.

H) Conduct environmental water analysis and seismic monitoring.

I) Technology transfer will include interface with industry on the LTFT and participation in technical meetings.

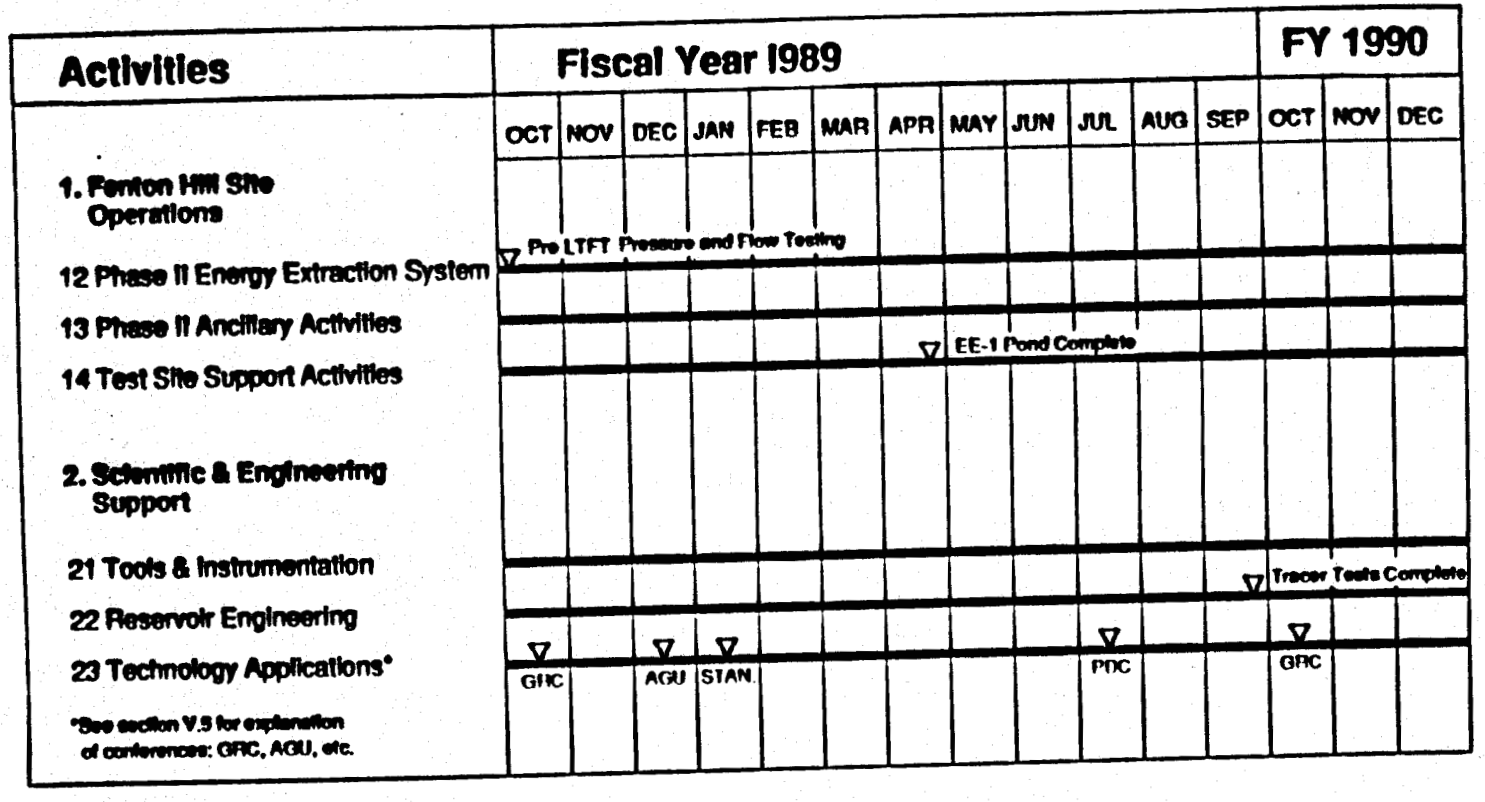
IV.6 Estimated Funding and Manpower Distribution

FY89 Funding Requirements Summary ($ Thousand)

Project	Management	In-House Effort	Subcontracted Effort	LTFT Equipment	TOTAL
Fenton Hill Operations	100	1500	500	600	2700
Scientific and Engineering Support	90	760	50		900
TOTAL	190	2260	550	600	3600

Funding Year Manpower Requirements (average for entire fiscal year)

Project	Management	In-House	Subcontract Effort	TOTAL
Fenton Hill Operations	0.8	9.2	5.0	15.0
Scientific and Engineering Support	0.7	4.3	1.0	6.0
TOTAL	1.5	13.5	6.0	21.0



Funding Year Milestone Schedule

V. MANAGEMENT

V.1 Description of Program Management

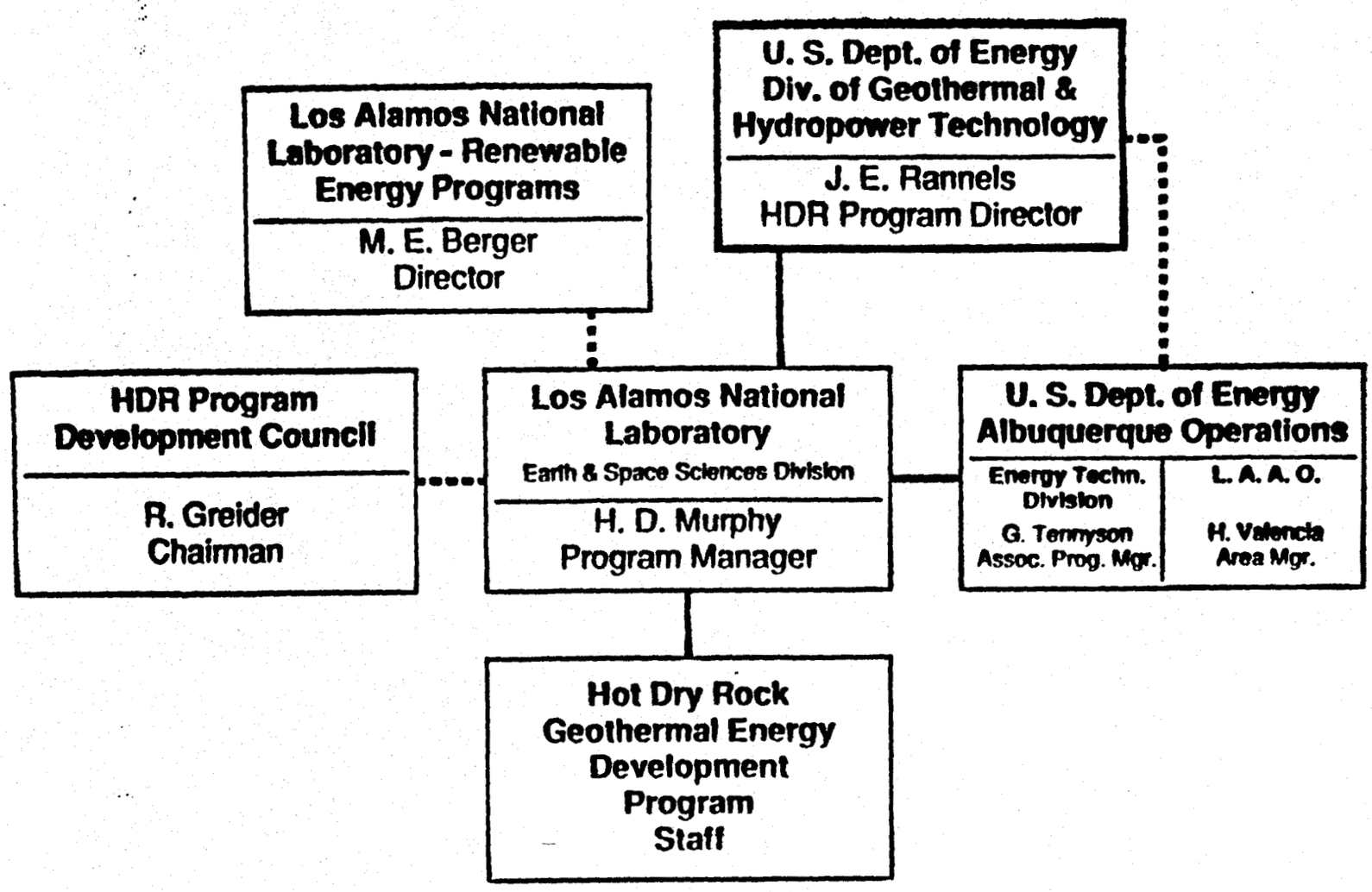
As shown in the accompanying organization chart, the HDR Program continues to be field-managed jointly by the Los Alamos National Laboratory (LANL) and the DOE Albuquerque Operations Office (DOE/ALO), under the overall purview of the HDR Program Director in the DOE Geothermal Technology Division (DOE/GTD). The LANL management function encompasses two categories of effort: (a) cognizant program management per se and (b) management support and services.

Cognizant program management, organized as shown on the attached figure, is responsible for overseeing controlling, representing, and communicating on behalf of the Program in both the technical and the administrative sense. Among the specific responsibilities of management are:

* day-to-day programmatic direction of the Program's functional personnel;
* technical and fiscal program planning, including the Annual Operating Plan (AOP); technical plans for LTFT installation and major experiments; and budgetary accounting analyses;
* informal daily telecons, quarterly and annual written reports, and semiannual presentations to DOE/GTD;
* providing information or supporting requests from DOE/GTD;
* supporting liaison with other HDR-related research programs;
* in concert with DOE/ALO, interfacing with, and providing any required reports to local government agencies and locally cognizant offices of other federal agencies including the USGS, US Forest Service, EPA, BLM, New Mexico State Engineer, and New Mexico State Bureau of Economic Geology;
* assisting the Los Alamos Area Office of DOE/LAAO in the processing and approval of major subcontracts and procurements, and supporting that office in the settlement of any claims or labor disputes arising in connection with the HDR Program;
* supporting liaison with, and fostering technology transfer to, interested industrial organizations;
* providing information, and tours when appropriate, to ranking governmental, industrial and institutional visitors;
* conducting reviews of the Program with the HDR Program Development Council; and
* coordination of the HDR Program with other LANL programs and representation of the Program to LANL upper management.

Management support and services provides:

* LANL upper management attention to HDR Program matters, as required;



HDR Program Organization Chart

* procurement, personnel, clearance and badging, and legal services;
* editorial and publication support; and
* budgetary and accounting support.

V.2 Procurement Plan Summary for Funding Year ($ Thousands)

Projects	Procurement Cost ($K)	
1. Fenton Hill Operations		
a) Surface System	510	
b) Safety and Security	220	
c) Internal Support	109	
Subtotal		839
2. Scientific and Engineering Support		
a) Instrument Development		
b) Internal Support	58	
Subtotal		58
TOTAL		897

V.3 Subcontract Funding Distribution Summary ($ Thousands)

Task	HBCU	Other Universities	Small and Minority Business	Other Businesses	Internal	TOTAL
Hot Dry Rock Program	0	40	250	440	167	897

V.4 Schedule of Required Reports and Plans

A) Regular Reports to DOE/DGT
- Technical Status Report (TSR)
- Semiannual Program Reviews
- Annual Report
- Minutes of Program Development Council Meeting

B) Regular Reports to ALOO Mgt
- Formal Briefing to Mgr as required
- Minutes of Program Development Council Meetings

C) Regular Reports to Los Alamos Mgt
- Quarterly Status Reports
- Minutes of Program Development Council Meetings

D) Regular Reports to HDR Program Office
- Monthly Fenton Hill Operations Report

Quarterly Task Managers Reports
Minutes of Program Development Council Meetings

E) External
Quarterly TSR
Annual Report
Monthly Fenton Hill Water Consumption (NM State Engineer and ALOO)
Minutes of Program Development Council Meeting

F) Topical Reports
Technical Reports
Environmental Analyses (internal and external)
Water Discharge Reports (NM State Oil Conservation Division and ALOO)
Financial Status Report and Review Meetings (Controller, ESS-DO)
Technical Papers at Conferences and Seminars
Programmatic Trip Reports

V.5 Description and Schedule of Conference and Technical Reviews

Major FY89 Meetings

Meeting	Place	Date(s)
Geothermal Resources Council	San Diego, CA	October 1988
American Geophysical Union	San Francisco, CA	December 1988
Stanford University Res Eng Workshop	Stanford, CA	January 1989
DOE Geothermal Prog Rev VII	San Francisco, CA	Spring 1989
Program Development Council Meeting	To be Determined	Summer 1989
DOE Semiannual Tech Rev	Washington, DC	Fall 1989

VI OUTYEAR RESEARCH PLAN

VI.1 Strategy and Key Issues

A) Run Long-Term Flow Test to establish reservoir characteristics.
B) Complete systems study and final report.
C) Carry out extensive technology exchange program.

VI.2 Program Description

The primary objective of the Hot Dry Rock Fenton Hill Project Phase II effort is to demonstrate creation and control of a multiply-fractured reservoir with extended longevity by creating a larger system (20 to 35 MW_t) with a projected life in excess of 10 years. At the time this large reservoir was designed, it was thought that 10 to 15 discrete, parallel

planar fractures would be required. However, subsequent fracture maps showed that the fractures induced were not simple, tensile-failure fractures, but were instead large 3-dimensional zones of fractures. Because of schedule and cost considerations, only one such zone was linked by two wells, and while large, it is anticipated that less than 20 MW_t will be produced. The current primary objective, at this lower production rate, is to operate a Long-Term Flow Test to determine the heat energy available and provide data for reservoir model and diagnostics confirmation. The test will be operated for at least one year, or longer if necessary, to observe thermal drawdown, i.e., the decrease in downhole production well temperature. This drawdown signifies the first evidence of the useful lifetime of the reservoir, and from it are derived estimates of available heat energy.

Design of the Phase II Surface System LTFT began in FY87. Procurements for some of the new components and the installation and testing will be continued in FY89. Expensive components, such as the high-pressure pumps, will be partially procured in FY89, and completed in FY90, when funding permits. As soon as the surface system has been completed, instrumented and tested, the LTFT will be initiated to investigate the thermal, mechanical, and chemical behavior of the system and to permit estimation of useful lifetime and economic viability.

Environmental surveillance will continue, particularly for possible seismic and hydrologic effects. This effort will not only ensure protection of the Fenton Hill environment, but also provide a documented case history for use in future environmental analyses, assessments, and impact statements. Environmental concerns of HDR are minimal. There are essentially no releases to the biosphere because the water produced from the reservoir is reinjected. Thus the water is used over and over again, and not ordinarily exposed to the environment. Furthermore, on the few occasions when the water is released to the environment because of the short-term nature of the experiment being conducted, the water is of sufficient quality that it already meets the standards of the New Mexico Environmental Improvement Department for release. Total dissolved solids is less than 4000 ppm (0.4%) and consist primarily of innocuous species such as silica and bicarbonate.

LANL routinely monitors the seismicity associated with energy production and has found that the largest seismic event caused by HDR operations is measured as a 1 on the Richter scale, about 100 times less energetic than earthquakes that are perceptible to bystanders, and 10,000 times less energetic than damage-causing earthquakes.

VI.3 Overall Outyear Schedule and Major Milestones

Project	FY90	FY91	FY92
Fenton Hill Operations	K1 K3	K4	
Scientific and Engineering Support	K2		K5

K1 = Complete surface system installation.
K2 = Complete water loss reservoir experiments.
K3 = Start LTFT.
K4 = Complete LTFT.
K5 = Complete LTFT analysis.

VI.4 Projected Outyear Funding ($ millions)

Project	FY90	FY91	FY92
Fenton Hill Operations	2.7	3.9	3.9
Scientific and Engineering Support	0.9	1.1	1.1
TOTAL	3.6	5.0	5.0